

## Two new species of Sphaerodoridae (Annelida) from the Gulf of Thailand

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### Abstract

Despite being a great species-rich area, the Gulf of Thailand has been relatively poorly studied and new species are awaiting to be described. In the present study two new species of Sphaerodoridae (Annelida), *Geminofilum thailandica* sp. nov. and *Sphaerodoridium songkhlaensis* sp. nov. were collected in shallow soft bottoms at Songkhla Sea. *Geminofilum thailandica* sp. nov. is characterised by bearing sessile and elongated dorsal macrotubercles, arranged in two transverse rows per segment, lacking other dorsal papillae, having parapodia with a single papilla at the base and compound chaetae with blades 4–6 times as long as wide and serration showing variation within fascicles. *Sphaerodoridium songkhlaensis* sp. nov. can be distinguished from other congeners by the singular morphology of the short stalked dorsal macrotubercles as inverted cones, with a conspicuous rim encircling the flattened distal surface, and two longitudinal rows of smaller sessile tubercles, as inverted cones, along ventrum, with four pairs of tubercles per segment. Chaetae show variation in the serration within fascicles. The present study highlights the need for further biodiversity studies on benthic communities in this area.

**Key words:** *Geminofilum*, *Sphaerodoridium*, Sphaerodoridae, new species, Songkhla Sea, Thailand, morphospecies

### Introduction

Sphaerodorids (Sphaerodoridae, Annelida) are scarce and understudied in Thailand, in both the Andaman Sea and the Gulf of Thailand. The only published records of members of this family of benthic marine worms are those from Bakken (2002), who studied the sphaerodorids collected for the project ‘Biodiversity of the Andaman Sea Shelf (BIOSHELF)’ during 1996–2000, (Aungtonya *et al.* 2000; Aungtonya & Eibye-Jacobsen 2002) at depths down to 1000 m within the Thai Economic Exclusive Zone. Bakken (2002) reported five species, that have been recently moved to different genera (after Capa *et al.* 2018, 2019). These are *Sphaerodoridium andamanense* (Bakken, 2002), *Sphaerodorum phuketensis* (Bakken, 2002) two species of *Sphaerephesia* Fauchald, 1972 (*sensu* Capa *et al.* 2019) and one of *Geminofilum* Capa *et al.* 2019.

The benthic biodiversity of the Songkhla Sea has been neglected and the few studies to date have focused on the Songkhla Lake (Angsupanich *et al.* 2006; Ariyama *et al.* 2010; Wongkamhaeng *et al.* 2014) and Ko Nu, the nearshore Island (Rodchareon 2009).

Since 2010, Thailand has been giving licenses for petroleum exploration in some areas within the Songkhla Sea. Consequently, intensive studies on marine environment and benthic biodiversity were imposed in order to measure the impact of petroleum concession. Many stations have been surveyed before the exploration and during operation production process providing a good opportunity to collect benthic and plankton samples to establish a base line for long term monitoring of Songkhla Sea.

The area within 500 m from petroleum platforms is protected by laws and all other activities, including trawling, are not allowed. The species richness and abundance of benthic species around the protected zone of the pe-

troleum platforms have been assessed to be higher than outside petroleum concession platform. So far, more than 400 polychaete morphospecies within over 200 genera belonging to 48 families have been found. Many of these species could not be identified to current nominal species, meaning they are potentially new records in the area or new species (Plathong, in prep.).

In the present study, samples collected from two main projects in the Songkhla Sea, Gulf of Thailand were sorted and examined in search for sphaerodorids. The first project “Monitoring Environmental Projects in the Petroleum Production Area in Songkhla Sea”, undertaken between 2011–2019 targeted to assess benthic diversity in several stations among oil extraction areas of Coastal Energy Company (CEC), Thailand. The second project “Marine and Coastal Resources Databases and Marine Community under Petroleum Platform in Songkhla Province”, aimed to explore the seasonal variation of benthic fauna adjacent to the southern province of Songkhla between 2012–2016. The study on Sphaerodoridae is the beginning of a set of systematic papers on polychaetes from Songkhla Sea, including the description of new species. Estimations indicate there are several undescribed species from several other families.

## Material and methods

Samples were collected at 98 stations from Songkhla Sea, the southern Gulf of Thailand between 2011–2019 (7°14'21"–7°49'212" N; 100°24'42"–100°49'1" E) with a Van Veen grab (0.1 m<sup>2</sup>) at depths ranging from 9.5 to 27.0 m (Fig. 1). The samples were sieved in the field with 2.0 mm, 1.0 mm and 0.5 mm meshes. Water and sediment from the grab sample were passed through a 300 µm mesh sieve and fixed with 4% formaldehyde in seawater solution. In the laboratory, samples were washed with freshwater and transferred to 70% ethanol. Specimens were sorted and examined under dissection and compound light microscope. The type specimens were deposited in the Princess Maha Chakri Sirindhorn Natural History Museum (PSUZY), Prince of Songkla University, Thailand; Museo Nacional de Ciencias Naturales (MNCN), Madrid, Spain; and the Australian Museum (AM) Sydney, Australia. Additional non-type specimens, were also deposited at the PSUZY.

Eight specimens of *Sphaerodoridium* and one specimen of *Geminofilum* were used for Scanning Electron Microscopy (SEM). They were dehydrated in 100% ethanol before the critical point dried, and then mounted onto SEM stubs and coated with gold (300–400 Å). SEM photographs were taken with a JEOL JSM-5800LV microscope and Apeo-Field Emission Scanning Electron Microscope (FESEM) at the Office of Scientific Instrument and Testing (OSIT), PSU, Thailand. and a HITACHI S-3400N microscope at University of the Balearic Islands (UIB), Spain.

Abbreviations used in figures:

<b>1–9</b>	chaetigers 1–9
<b>1a, 1b</b>	rows of dorsal macrotubercles in chaetiger 1 (and subsequent)
<b>la</b>	lateral antenna
<b>ma</b>	median antenna
<b>mac</b>	macrotubercle
<b>mo</b>	mouth
<b>pa</b>	palp
<b>pp</b>	parapodial papilla
<b>tc</b>	tentacular cirrus
<b>vc</b>	ventral cirrus

## Systematics

### Family Sphaerodoridae Malmgren, 1867

#### Genus *Geminofilum* Capa *et al.*, 2019

*Geminofilum* Capa *et al.*, 2019: 31.

*Sphaerodoropsis* Hartman & Fauchald, 1971: 69 (in part); Fauchald, 1974: 261 (in part); Borowski, 1994: 23 (in part); Moreira, 2012: 30 (in part); Capa *et al.*, 2014: 18 (in part).

**Type species.** *Sphaerodorum distichum* (Eliason, 1962)

**Diagnosis.** Body short and cylindrical. Head with a median and a pair of lateral antennae; antenniform papillae absent or present; all appendages short. Tubercles sessile, spherical or hemispherical, arranged in two transversal rows per segment. Additional epithelial papillae on dorsal (sometimes absent) and ventral surfaces. Parapodia with elongated ventral cirri, as long as acicular lobe. Stout hooks in anterior chaetigers absent. All chaetae compound, unidentate, with serrated edge (after Capa *et al.* 2019).

***Geminofilum thailandica* sp. nov.**

Figs 1A, 2–4, 5A–D

**Material examined.** Two specimens, collected from Songkhla Sea, the Gulf of Thailand, Western Pacific. Coll. MEM (Marine Ecoscience Management Co., Ltd.), mud mixed with sand and shells. Holotype: PSUZC-POL-0020 (1 spec.), S21 (7°33'17" N, 100°46'43" E), 21 Aug. 2013, 24.0 m, complete specimen, female. Paratype: PSUZC-POL-0057 (1 spec. on SEM stub), S08 (7°29'10" N, 100°47'06" E), 14 Oct. 2015, 25.0 m, complete specimen, female.

**Type locality.** Songkhla Sea, Gulf of Thailand (Fig. 1A).

**Diagnosis.** Body eight times longer than wide, cylindrical, up to 2.9 mm long and 350 µm wide. Prostomial appendages smooth, lacking spurs or basal papillae. Dorsal macrotubercles sessile, ellipsoid, arranged in two transverse rows per segment, with eight and seven macrotubercles each, from segment 3. Dorsum without additional papillae. Ventrums with ca. 12 ellipsoid papillae per segment, arranged in three transverse rows. Parapodia with a spherical papilla on the base of anterior side from chaetiger 3. Acicular lobe from chaetiger 2. Compound chaetae in all parapodia, 5–7, with blades 4–6 times as long as wide, and with variation in the length of the serration along the edge within fascicles.

**Description.** Holotype cylindrical, complete with 2.9 mm long and 0.47 mm wide, up to 21 chaetigers, in poor conditions. Dorsum convex, ventrum flattened. Segmentation inconspicuous. Preserved specimen without pigmentation. One pair of sub-epithelial eyes in head, black in preserved holotype (Fig. 2A–B); muscular pharynx not seen. Anterior end bluntly rounded; prostomium and peristomium indistinct (Figs 2A–B, 3A). Appendages digitiform, about twice as long as wide, smooth, without basal spurs. Some scattered additional papillae behind lateral and median antennae. Tentacular cirri not clearly distinct. Dorsal macrotubercles arranged in two transverse rows per segment (Figs 3A, 5A). Macrotubercles sessile, hemi-ellipsoid, longer than wide (but collapsed in SEM photographs, Fig. 3A–B, D). First chaetiger with five macrotubercles in anterior row, lateral and middle tubercles smaller, and posterior row with seven larger macrotubercles (Fig. 3B). Second chaetiger with seven and eight tubercles on each anterior and posterior rows, arranged in zig-zag pattern; tubercles enlarging in size from lateral to mid-dorsal position (Fig. 3B). Following chaetigers with eight macrotubercles between parapodia and seven in posterior transversal row (Fig. 5A). Additional dorsal papillae absent (Figs 3A, 5A). Ventrums with ca. 12 spherical papillae per segment arranged in three transverse rows (Figs 3D, 5B). Additional large and spherical ventral papilla at the base of each parapodia from chaetiger 3 (Fig. 3A, D). Parapodia about twice as long as wide, with digitiform acicular lobe, from chaetiger 2; ventral cirri digitiform, enlarged at the base on mid-body chaetigers from chaetiger 3. Parapodia with at least one papilla on the base of the anterior side (Figs 3A, 4D, 5C–D). Compound chaetae present in all chaetigers, arranged in curved row posterior to acicular lobe, numbering 5–7 per fascicle (Figs 4A–D, 5C–D). Shaft with slender distal end; blades slender, ranging 4–6 times longer than maximum width, with fine serration along all their edge (Fig. 4E–G). A few spines on distal side of opposite edge (Fig. 4G). Pygidium blunt with ventral pygidial cirrus and a pair of rounded terminal papillae, similar in shape but smaller than dorsal macrotubercles (Fig. 3E).

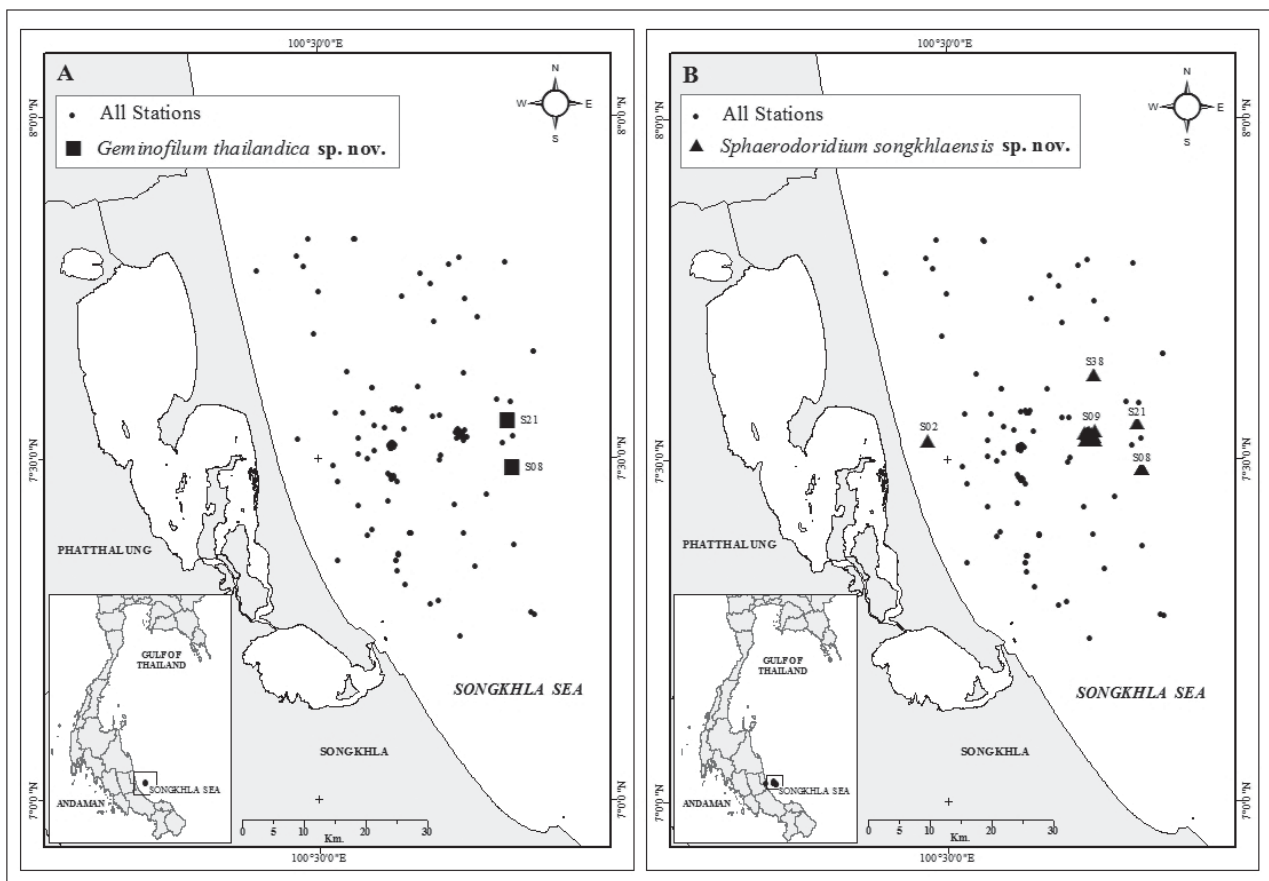
Female with oblong eggs scattered in coelomic cavity (Fig. 2A). Genital openings or sexual structures not observed.

Methyl green staining: only heavily stained on macrotubercles (Fig. 2B).

**Variation.** Paratype 2.1 mm long, 0.3 mm wide, female; 20 chaetigers. Anterior end invaginated as in holotype, anterior appendages as described (tentacular cirri not observed). Other morphological traits such as the number and arrangement of dorsal and ventral tubercles, the parapodial and chaetal morphology does not vary with respect to that described for the holotype.

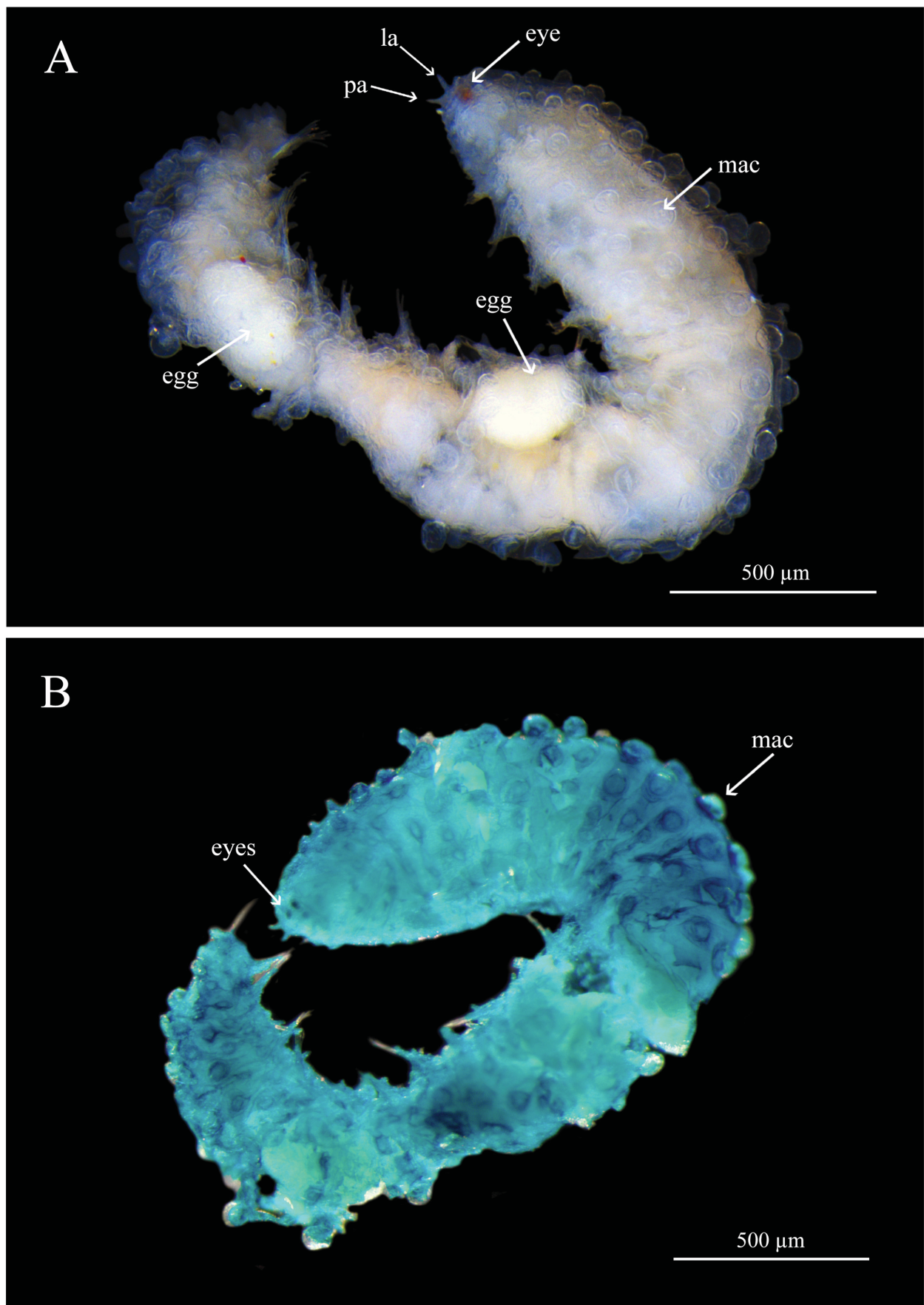
**Remarks.** *Geminofilum thailandica* **sp. nov.** is characterised by the presence of dorsal macrotubercles arranged in double transverse rows of, being elongated and ellipsoid in shape, the absence of additional dorsal epithelial papillae, the arrangement of transverse rows of spherical ventral papillae, being those near the base of parapodia much larger, and the presence of chaetae with blades 4–6 times as long as wide. Intraspecific variation could not be assessed in *G. thailandica* **sp. nov.** due to low number of specimens found, and some details are awkward to see in the type material given its size and not optimal conditions. Some of the features mentioned in the description (e.g., the number, arrangement and relative size of head appendages in a contracted anterior end and the number of macrotubercles in the first chaetiger) should be verified when additional material is found.

There are 15 species currently accepted within the genus *Geminofilum* (Capa *et al.* 2019). They are mostly characterised by the arrangement of dorsal and sessile macrotubercles in double transverse rows per segment. Most species bear spherical or hemispherical macrotubercles, but macrotubercles in *G. thailandica* **sp. nov.** are elongated, longer than wide, especially in mid-body segments, such as those described for *G. megatuberculata* (Capa & Bakken, 2015) from Bass Strait, Australia. Both species also share the number and arrangement of these dorsal tubercles (8+7 in mid-body segments), compound chaetae serrated along all blade length, with some spines on opposite edge, and a pair of black subepithelial eyes. *Geminofilum thailandica* **sp. nov.** is distinguished from *G. megatuberculata* in the absence of dorsal papillae between macrotubercles, unlike the latter species that bears 2–3 transverse rows of small spherical papillae per segment. In addition, *G. thailandica* **sp. nov.** bears only one parapodial papilla, while *G. megatuberculata* bears two. The new species also has longer blades than the Australian congener, being between 4–6 times as long as wide in *G. thailandica* **sp. nov.** and 2–3 times as long as wide in *G. megatuberculata*. Sexual features have not been clearly identified in *G. thailandica* **sp. nov.**, but both specimens studied are females and bear large spherical ventral papillae, near the base of parapodia from chaetiger 4 to at least 9, a feature that if related to pseudocopulation. In *G. megatuberculata* porous tubercles between chaetigers 5 and 6, were observed.



**FIGURE 1.** Sampling sites in the Songkhla Sea, Gulf of Thailand (dots). A. Stations where specimens of *Geminofilum thailandica* **sp. nov.** were collected (squares) B. Stations where *Sphaerodoridium songkhlaensis* **sp. nov.** were collected (triangles).

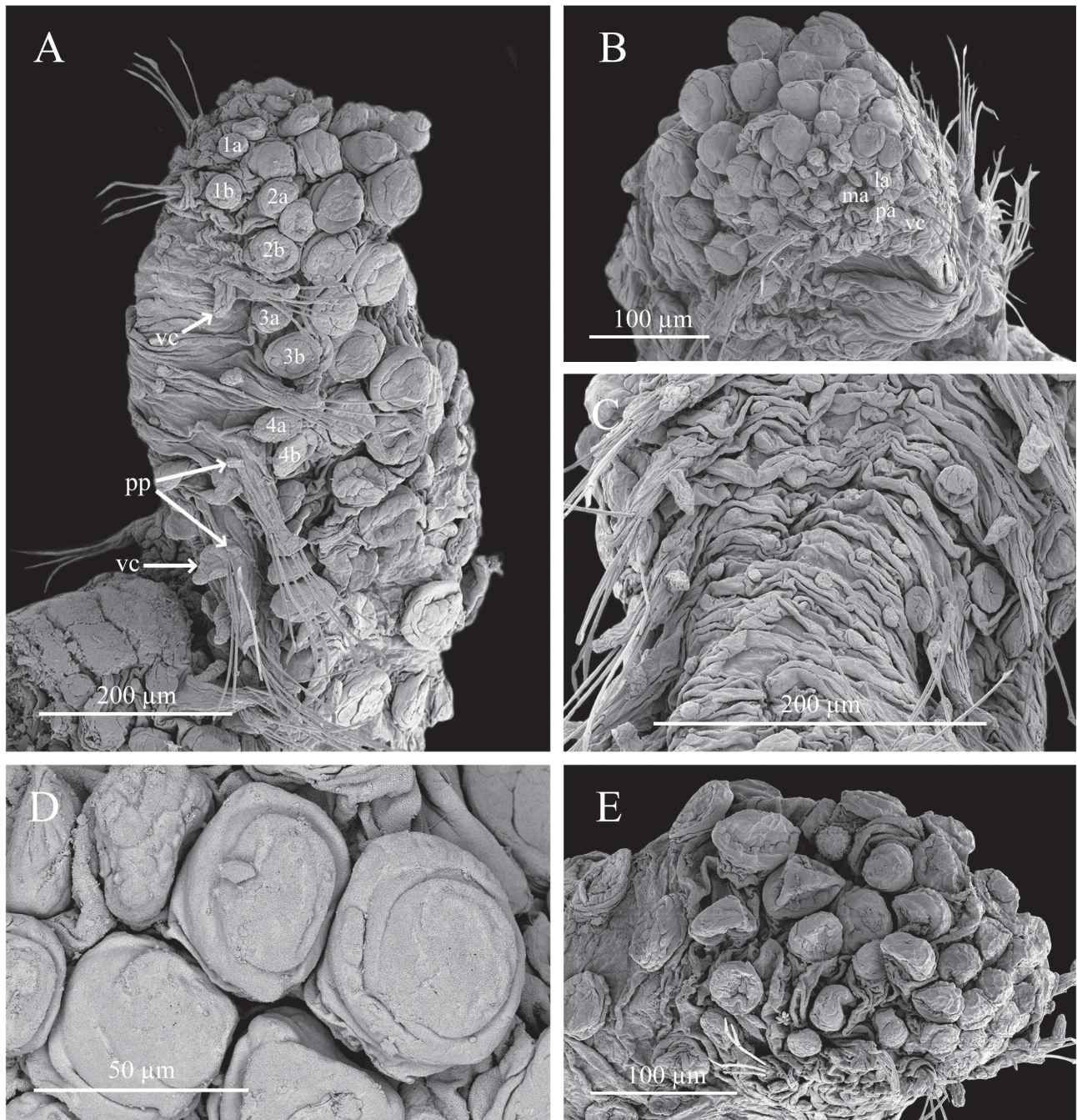




**FIGURE 2.** Photographs of *Geminofilum thailandica* **sp. nov.** (Holotype, PSUZC-POL-0020). A. Preserved in alcohol; B. Methyl green stained. Abbreviations: lateral antennae la, macrotubercles mac, palps pa.

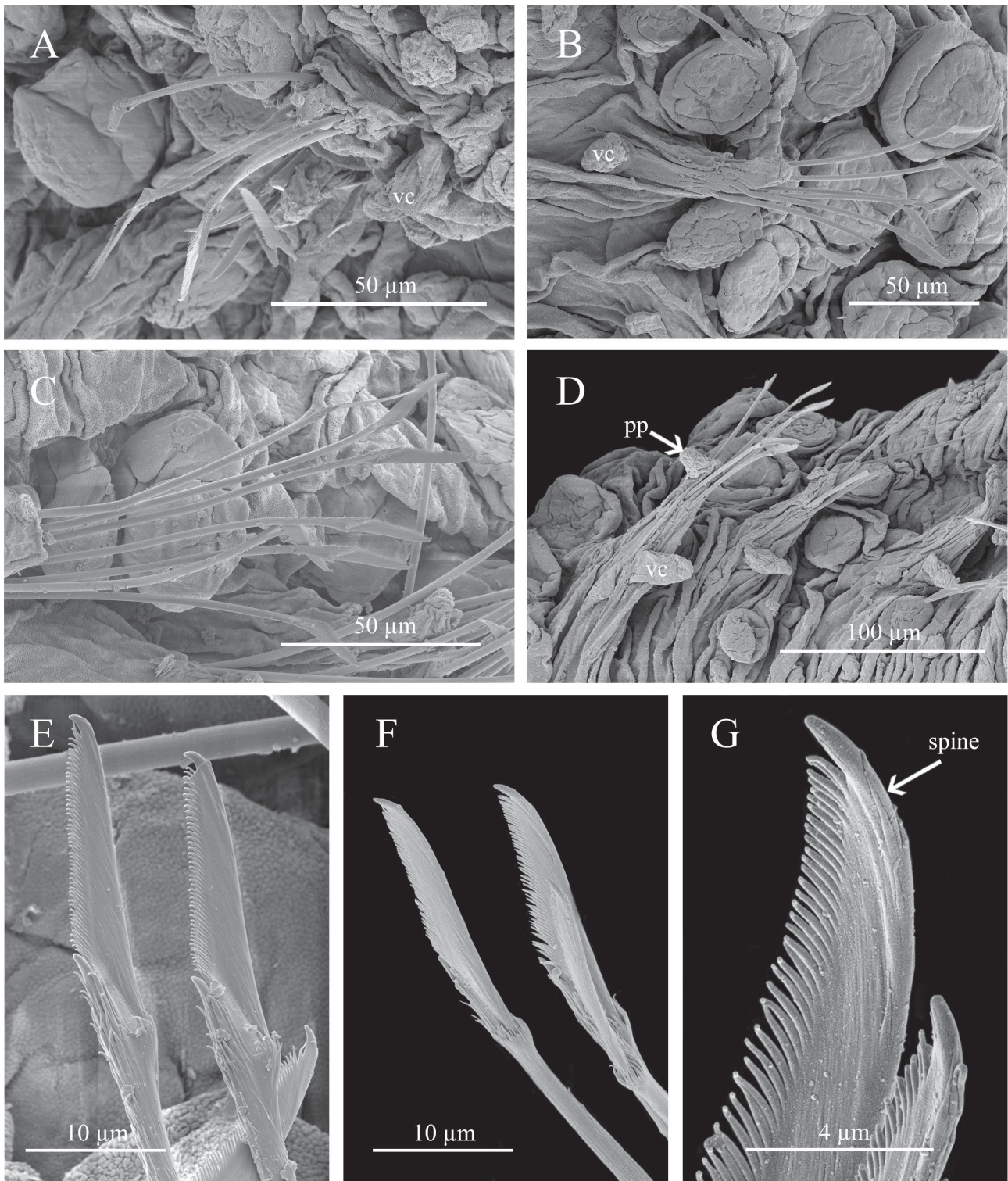


Other species of *Geminofilum* with similar number of dorsal macrotubercles seemingly presenting two more macrotubercles in one of the dorsal trasverse rows (8+7, instead of 6+7) are *G. arctowskiensis* (Hartmann-Schröder & Rosenfeldt, 1988), from South Shetland Islands; *G. bisphaeroserialis* (Hartmann-Schröder, 1974) from South Africa; *G. garciaalvarezi* (Moreira; Cacabelos & Troncoso, 2004), from the NW of Spain (Hartmann-Schröder 1974; Hartmann-Schröder & Rosenfeldt 1988; Moreira *et al.* 2004). *Geminofilum thailandica* **sp. nov.** is distinguished from all these species, from distant world localities, in the apparent complete absence of additional dorsal papillae in our species, while *G. arctowskiensis*, *G. bisphaeroserialis* and *G. garciaalvarezi* bear some scattered spherical papillae along with the macrotubercles. Moreover, chaetal blades are shorter in *G. arctowskiensis*, *G. bisphaeroserialis* and *G. garciaalvarezi* than in the new species.



**FIGURE 3.** Scanning electron micrographs of *Geminofilum thailandica* **sp. nov.** (PSUZC-POL-0057). A. Anterior end, lateral view; B. Anterior end, frontal view; C. Macrotubercles of mid chaetigers, top view; D. Midbody chaetigers, ventral view; E. Posterior end, back view. Abbreviations: anterior row of macrotubercles in chaetigers 1–4 respectively 1a–4a, posterior row of macrotubercles in chaetigers 1–4 respectively 1b–4b, lateral antenna la, median antenna ma, palp pa, parapodial papilla pp, ventral cirrus vc.





**FIGURE 4.** Scanning electron micrographs of *Geminofilum thailandica* sp. nov. (PSUZC-POL-0057). A. Parapodium of first chaetiger, anterior view; B. Parapodium chaetiger 3, anterior view; C. Chaetal fascicle, parapodium chaetiger 4; D. Parapodia mid chaetiger, ventral view; E. Compound chaetae, chaetiger 4; F. Compound chaetae, mid-body chaetiger; G. Detail of distal part of blades. Abbreviations: parapodial papilla pp, ventral cirrus vc.

**Etymology.** The species is named after Thailand, the country in which it was collected.

**Distribution.** Only known from type locality, the Songkhla Sea, Gulf of Thailand (Fig. 1A).

**Habitat.** Found at 24–25 m deep, in muddy mixed with sand and biogenic soft bottoms.

## Genus *Sphaerodoridium* Lützen, 1961

*Sphaerodoridium* Lützen, 1961; Fauchald, 1974: 270 (in part); Capa *et al.*, 2019: 66.

*Sphaerodoropsis* Hartman & Fauchald, 1971: 69 (in part); Fauchald, 1974: 261 (in part); Borowski, 1994: 23 (in part); Moreira, 2012: 30 (in part); Capa *et al.*, 2014: 17 (in part).

**Type species.** *Sphaerodorum clapedii* Greeff, 1866.

**Diagnosis.** Body short and ovoid, some forms slender. Prostomial appendages short, spherical or digitiform; median antenna shorter or as long as lateral antennae; antenniform papillae absent or present. Macrotubercles sessile or stalked; smooth, without terminal papilla, arranged in more or less clear longitudinal rows, one transverse row per segment, with at least seven macrotubercles each. Microtubercles absent. Additional papillae over body surface and parapodia. Parapodia with compound chaetae; stout hooks in anterior chaetigers absent (after Capa *et al.* 2019).

### *Sphaerodoridium songkhlaensis* sp. nov.

Figs 1B, 5E–H, 6–10

**Material examined.** 48 specimens from Songkhla Sea, Gulf of Thailand (Table 1). All specimens complete, from muddy mixed with sand and shells; coll. Marine Ecosearch Management Company (MEM). Holotype: PSUZC-POL-0010 (1 spec.), S09-6 (7°32'13" N, 100°42'21" E), 17 Feb 2015, 23.6 m. Paratypes: PSUZC-POL-0011 (1 spec. on SEM stub), S09-3 (7°32'01" N, 100°42'42" E), 18 Mar 2013, 24.0 m; PSUZC-POL-0012 (1 spec. on SEM stub), S08 (7°29'10" E, 100°47'06" E), 16 Oct 2013, 25.0 m; PSUZC-POL-0013 (1 spec. on SEM stub), S08 (7°29'10" E, 100°47'06" E), 28 Jan 2015, 25.0 m; PSUZC-POL-0014 (1 spec. on SEM stub), S08 (7°29'10" E, 100°47'06" E), 18 May 2016, 25.0 m; PSUZC-POL-0015 (1 spec. on SEM stub), S09-20 (7°31'44" N, 100°42'13" E), 23 Mar 2017, 24.0 m; PSUZC-POL-0016 (1 spec.), S09-8 (7°32'22" N, 100°42'30" E), 17 Mar 2013, 23.9 m; PSUZC-POL-0017 (1 spec.), S09-12 (7°31'56" N, 100°42'24" E), 17 Mar 2013, 23.8 m; PSUZC-POL-0018 (1 spec.), S09-5 (7°32'01" N, 100°42'30" E), 2 Mar 2016, 24.0 m; PSUZC-POL-0019 (1 spec. on SEM stub), S09-1 (7°32'13" N, 100°42'42" E), 17 Aug 2018, 24.0 m; PSUZC-POL-0063 (1 spec.), S09-16 (7°32'30" N, 100°42'59" E), 18 Feb 2015, 24.0 m; PSUZC-POL-0064 (3 specs, 2 on SEM stub), S09-5 (7°32'01" N, 100°42'30" E), 23 Aug 2019, 24.0 m; PSUZC-POL-0065 (1 spec.), S09-18 (7°31'44" N, 100°42'59" E), 1 Mar 2011, 24.0 m; PSUZC-POL-0066 (1 spec.), S09-7 (7°32'19" N, 100°42'24" E), 7 Mar 2011, 23.7 m; PSUZC-POL-0067 (1 spec.), S38 (7°37'29" N, 100°42'53" E), 27 Sep 2011, 25.0 m; PSUZC-POL-0068 (1 spec.), S21 (7°33'17" N, 100°46'43" E), 9 Feb 2012, 24.0 m; PSUZC-POL-0069 (2 specs), S08 (7°29'10" N, 100°47'06" E), 21 Feb 2013, 25.0 m; PSUZC-POL-0070 (1 spec.), S02 (7°31'44" N, 100°28'15" E), 5 Jun 2014, 10.0 m; PSUZC-POL-0071 (1 spec.), S09-1 (7°32'13" N, 100°42'42" E), 24 Mar 2017, 24.0 m; PSUZC-POL-0072 (1 spec.), S09-4 (7°31'60" N, 100°42'39" E), 24 Mar 2017, 24.0 m; AM W.52921 (1 spec.), S08 (7°29'10" N, 100°47'06" E), 23 Mar 2013, 25.0 m; AM W.52922 (1 spec.), S09-22 (7°32'13" N, 100°42'30" E), 16 Aug 2018, 24.0 m; MNCN 16.01/18538 (1 spec.) S09-2 (7°32'04" N, 100°42'43" E), 24 Mar 2017, 24.0 m; MNCN 16.01/18539 (1 spec.), S09-3 (7°32'01" N, 100°42'42" E), 16 Aug 2018, 24.0 m.

**Additional material examined:** *Sphaerodoridium andamanense* Bakken *et al.*, 2002 (Holotype, PMBC 18540).

**Type locality.** Songkhla Sea, Gulf of Thailand (Fig. 1B) in Block G5/43 of petroleum concession area.

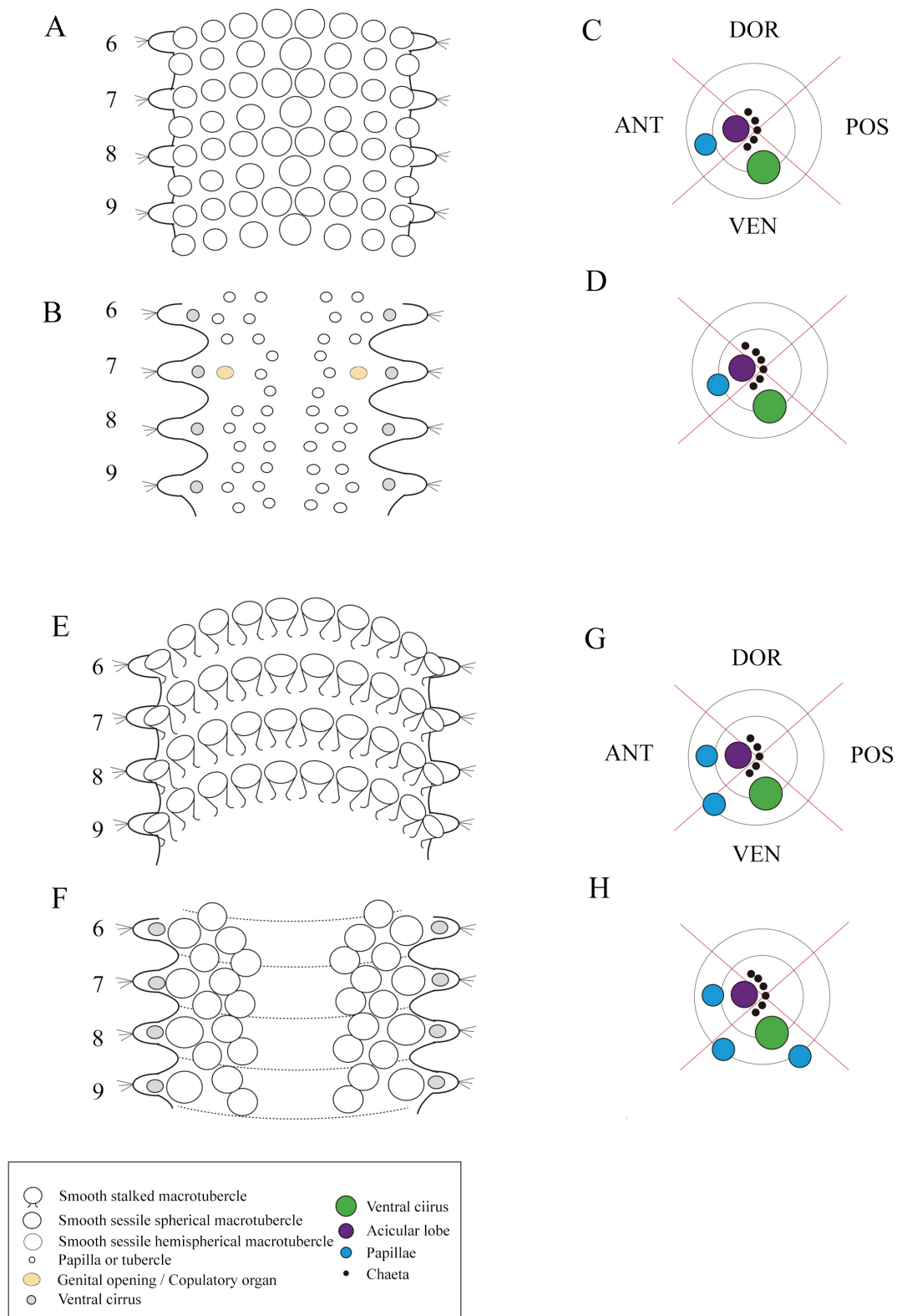
**Diagnosis.** Body short and ellipsoid, less than 2.0 mm long. Head appendages smooth and digitiform, without basal spurs. Dorsal macrotubercles with short stalk, and terminal papillae as inverted cones with a crenulated rim around distal almost circular surface; arranged in a single transverse row per segment with up to 10 macrotubercles. Dorsum without additional papillae. Ventrums with about eight large spherical papillae per segment, lateral larger, located near parapodial base, leaving a mid-ventral longitudinal gap; arranged in oblique rows. Parapodia with one or two spherical papillae on ventral and anterior surfaces. Acicular lobe from first segment. About 5–6 compound chaetae with medium blades (4–5 times as long as wide), showing intra-fascicle variation in serration (dorsal and ventral most chaetae with serration along complete edge; mid-chaetae with distal end without serration).

**Description.** Holotype with ellipsoid body, flat ventrum and convex dorsum; segmentation inconspicuous, 1.7 mm long, 0.47 mm wide with 18 chaetigers, female. (Figs 6A–B, 7A–C).

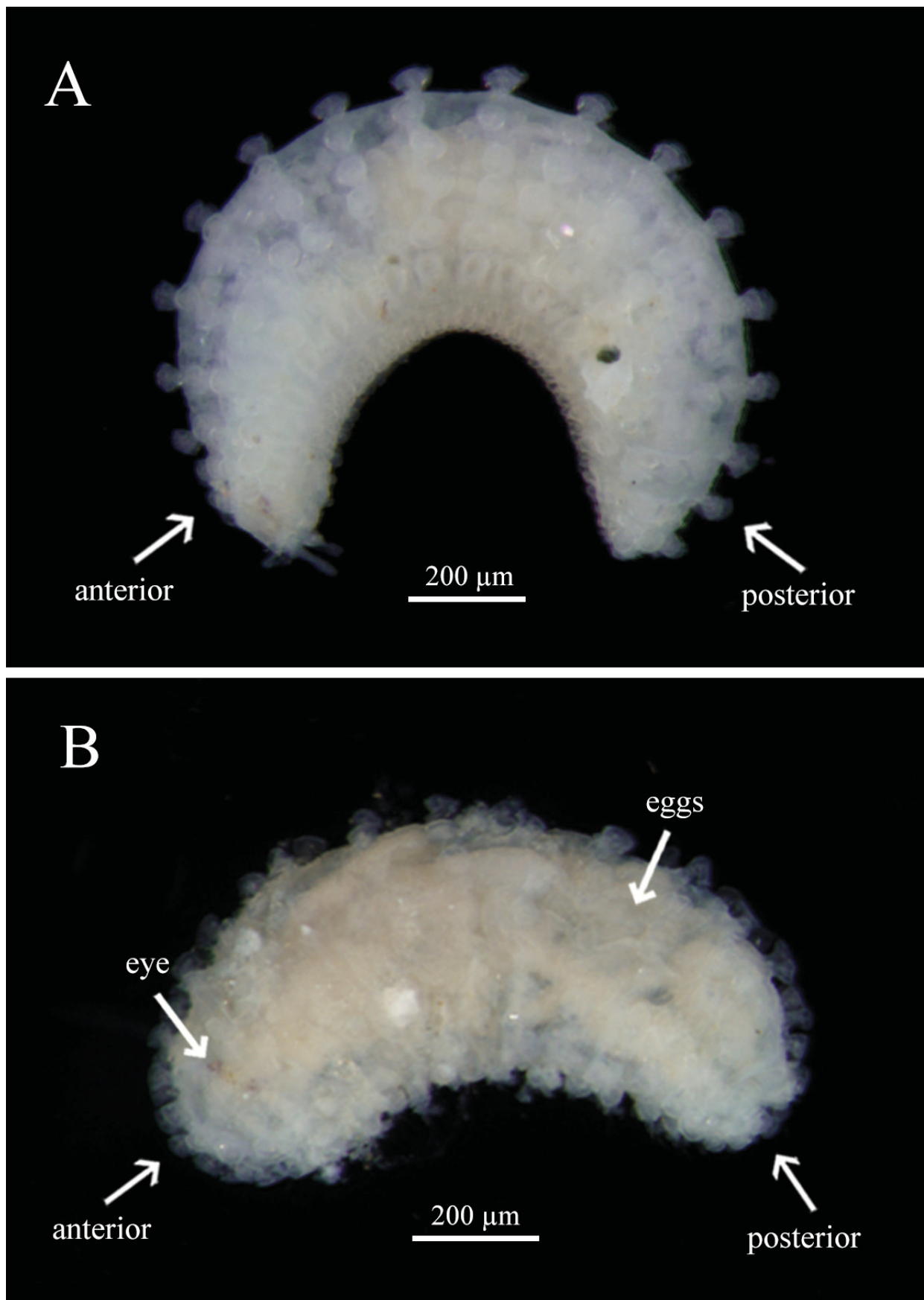
**TABLE 1.** Stations and data where the specimens of *Sphaerodoridium songkhlaensis* sp. nov. were collected in Songkhla Sea, Gulf of Thailand. (\*= specimen used for SEM).

Station code	Sampling Date/ Number of individual (s)	Latitude (North)	Longitude (East)	Depth (m)	Sediments
S02	5/6/2014 (1)	7°31'44"	100°28'15"	10.0	Fine and sticky mud with shells
S08	8/10/2012 (1), 21/3/2013 (2), 16/10/2013 (1*), 28/1/2015 (1*), 14/10/2015 (1), 18/5/2016 (1*)	7°29'10"	100°47'06"	25.0	Mud with shells
S09-1	7/3/2011 (1), 24/3/2017 (1), 17/8/2018 (2, 1*)	7°32'13"	100°42'42"	24.0	Mud with sand and shells
S09-2	24/3/2017 (2)	7°32'04"	100°42'43"	24.0	Mud with sand and shells
S09-3	18/3/2013 (1*), 16/8/2018 (2)	7°32'01"	100°42'42"	24.0	Mud with sand and shells
S09-4	24/3/2017 (1)	7°31'60"	100°42'39"	24.0	Mud with sand and shells
S09-5	7/3/2011 (2), 2/3/2016 (1), 17/8/2018 (1), 23/8/2019 (3, 2*)	7°32'01"	100°42'30"	24.0	Mud with sand and shells
S09-6	17/2/2015 (1)	7°32'13"	100°42'21"	23.6	Mud with sand and shells
S09-7	7/3/2011 (1)	7°32'19"	100°42'24"	23.7	Mud with sand and shells
S09-8	7/3/2011 (1), 17/3/2013 (1)	7°32'22"	100°42'30"	23.9	Mud with sand and shells
S09-9	7/3/2011 (1), 18/2/2015 (1), 24/3/2017 (2)	7°32'01"	100°42'51"	24.7	Mud with sand and shells
S09-12	2/3/2011 (3), 17/3/2013 (1)	7°31'56"	100°42'24"	23.8	Mud with sand and shells
S09-13	1/3/2011 (1)	7°32'20"	100°42'06"	24.0	Mud with sand and shells
S09-16	18/2/2015 (1)	7°32'30"	100°42'59"	24.0	Mud with sand and shells
S09-18	1/3/2011(1)	7°31'44"	100°42'59"	24.0	Mud with sand and shells
S09-20	1/3/2011 (1), 23/3/2017 (1*)	7°31'44"	100°42'13"	24.0	Mud with sand and shells
S09-22	16/8/2018 (1)	7°32'13"	100°42'30"	24.0	Mud with sand and shells
S21	9/2/2012 (1), 21/8/2012 (1), 9/3/2014 (1)	7°33'17"	100°46'43"	24.0	Mud with shells, the lower sediment is sticky mud
S38	27/9/2011 (2)	7°37'29"	100°42'53"	25.0	Mud with sand and shells





**FIGURE 5.** Stylised drawings. A–D. *Geminofilum thailandica* **sp. nov.** A. Dorsal tubercles of chaetigers 6–9; B. Ventral tubercles of chaetigers 6–9; C. Parapodial appendages and papillae in anterior chaetiger; D. Parapodial appendages and papillae in mid-body aposterior chaetiger; E–H. *Sphaerodoridium songkhlaensis* **sp. nov.** E. Dorsal tubercles of chaetigers 6–9; F. Ventral tubercles of chaetigers 6–9; G. Parapodial appendages and papillae in anterior chaetiger H. Parapodial appendages and papillae in mid-body and posterior chaetiger. The numbering system refers to chaetiger number, the concentric circles represent the volume of the parapodium (larger ones indicate basal and smaller distal areas) and the red axis are the imaginary lines dividing four sides of the parapodium: anterior ANT, dorsal DOR, posterior POS, ventral VEN.



**FIGURE 6.** Photographs of *Sphaerodoridium songkhlaensis* sp. nov. (A. PSUZC-POL-0013, B. PSUZC-POL-0019). A. Complete specimen, lateral view; B. Same, dorsal view.

Prostomium with five appendages, including a pair of palps, a pair of lateral antennae and a median antenna. All appendages smooth, digitiform, about three or four times as long as wide; without basal spurs. Antenniform papillae absent. A pair of tentacular cirri shorter than lateral antennae. Four additional spherical papillae in head region (Figs 8A–B, 10A). A pair of rounded and sub-epidermal eyes present, black after preservation (Fig. 6B).

Chaetiger 1, without macrotubercles, with four small papillae (Fig. 9A). Chaetiger 2 with six dorsal macrotubercles arranged in a single transverse row (six or seven in paratypes) (Fig. 9A). Chaetigers from the third with nine dorsal macrotubercles (Fig. 9A–C), up to 10 in mid-body chaetigers and decreasing in number in posterior chaetigers (Figs 5E, 7A–B, 9C). Macrotubercles as inverted cones with a crenulated rim and a flattened or convex distal end; with a short stalk (Fig. 9D). All macrotubercles attached to anterior edge of segments; all similar in size except for chaetiger 1 and posterior segments where slightly smaller. Additional dorsal epithelial tubercles absent (Figs 5E, 7A–B, 9A–C). Ventrum with two longitudinal bands of sessile tubercles, as inverted cones, along the body, next to base of parapodia (Figs 5F, 7C, 9E–F), with four pairs of tubercles per segment forming oblique rows closing posteriorly (Figs 5F, 9E–F). Parapodia short and cylindrical, as long as wide, wrinkled. Acicular lobe from chaetiger 1, longer than parapodial papillae and projecting distally. Ventral cirri conical larger than acicular lobe but projecting as much in mid-body and posterior segments. First three chaetigers with parapodia provided with one or two spherical papillae: one on antero-ventral surface, one on ventral surface (Fig. 5G); following chaetigers through with up to three papillae: one on anterior surface, two on ventral position, near the base of parapodia (Fig. 5H). Posterior one or two chaetigers lacking some papillae (Figs 5H, 10A). Each parapodium with 5–6 compound chaetae, arranged in a curved transverse row around acicular lobe (Figs 5G–H, 10A–C, E). Chaetae with blades 4–6 times longer than maximum width. Blades of each chaetiger with serration varying in length along cutting edge: one or two dorsal most chaetae with edge completely serrated; rest of chaetae with edge partially smooth (Fig. 10F–G). Pygidium terminal, with one mid-ventral digitiform anal cirrus projecting beyond last parapodia, flanked by two anal cirri similar in shape to dorsal macrotubercles (Fig. 7C).

Pharynx extending over two chaetigers. Females with “sexual structures”, as porous hemispherical papillae on base of parapodia of chaetiger 8 (Fig. 10C–D). Male copulatory organs present (?) on chaetiger 12 in paratype (Fig. 10E). Females with oblong eggs under translucent epithelium about 100–217  $\mu\text{m}$  in length (Fig. 6B).

**Variation.** Unlike the holotype, which is a relaxed and turgent individual, most specimens have contracted heads and therefore it is difficult to assess arrangement and relative length of head appendages. All examined specimens lack macrotubercles in chaetiger 1, and four head papillae are visible only in some individuals (due to contraction of anterior end). Number of dorsal macrotubercles in chaetiger 2 ranges from six to seven. Chaetiger 3 with nine dorsal tubercles and following with 9–10. Dorsal macrotubercles are similar in all the material examined, regardless station or year collected. The stalk is short and even some tubercles seem sessile; distal tubercle has an inverted cone shape with a distal epithelial rim encircling an almost flat surface. These features are visible under optic and also electronic microscopy. Ventral tubercles are smaller in size but resemble in shape (cone shape), the rim is inconspicuous.

**Etymology.** The species name refers to the Songkhla Sea, the type locality.

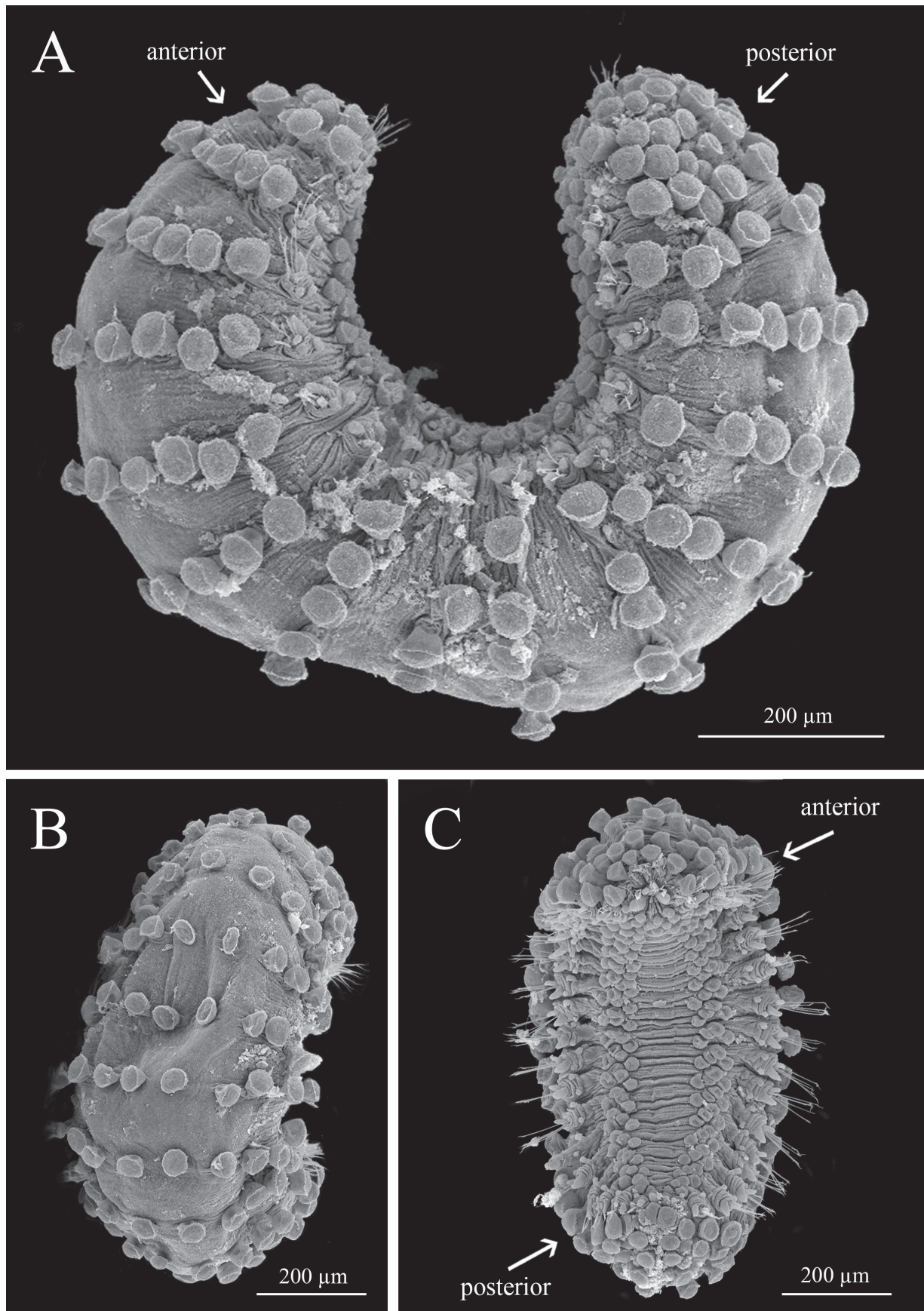
**Distribution:** Only known from type locality - Songkhla Sea, Gulf of Thailand (Fig. 1B).

**Habitat.** Found in muddy mixed with sand and shells.

**Remarks:** The definition and circumscription of the genus *Sphaerodoridium* has changed recently, after phylogenetic analyses of DNA sequences (Capa *et al.* 2019). Members of the previously considered *Sphaerodoropsis* Group 2 (Borowski, 1994), characterised by bearing sessile dorsal macrotubercles arranged in six or more longitudinal rows and only one transverse row per segment, were found nested in a clade among those previously considered *Sphaerodoridium*, with more seven longitudinal rows of dorsal stalked macrotubercles (Capa *et al.* 2019). The current diagnostic feature for *Sphaerodoridium* deals with the number of longitudinal rows of macrotubercles (over six) rather than their morphology (including both species with sessile and stalked macrotubercles). The number of accepted species in the genus is now 22, and none of them has been reported in the Gulf of Thailand before.

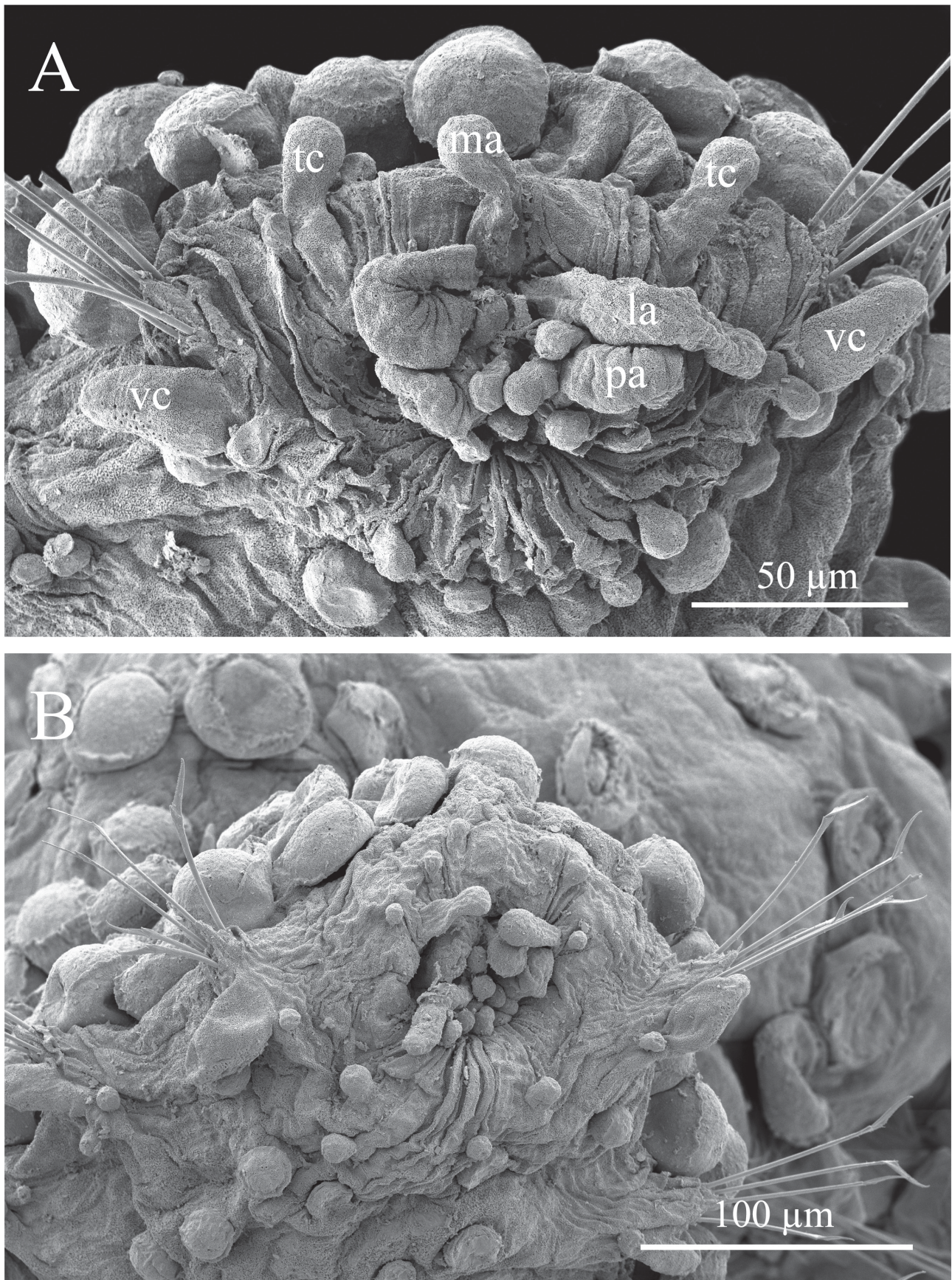
*Sphaerodoridium songkhlaensis* **sp. nov.** is characterized by the singular shape of the dorsal macrotubercles (as an inverted cone, with a conspicuous rim encircling the flattened distal surface) and the type of chaetae (with different morphologies on the same fascicle). There are two species of *Sphaerodoridium* and one of *Clavodorum* (*sensu* Capa *et al.* 2019) with similar dorsal macrotubercles (stalked and resembling an inverted cone or bell). These are *Sphaerodoridium campanulata* Borowski, 1994 from deep-sea sediments (1463 m) in Peru Basin, *Sphaerodoridium andamanense* Bakken, 2002, from the Andaman sea, Thailand (29 m), and *Clavodorum antarcticum*





**FIGURE 7.** Scanning electron micrographs of *Sphaerodoridium songkhlaensis* **sp. nov.** (A, B PSUZC-POL-0011, C PSUZC-POL-0012). A. Complete specimen, lateral view; B. Same, dorsal view; C. Complete specimen, ventral view.

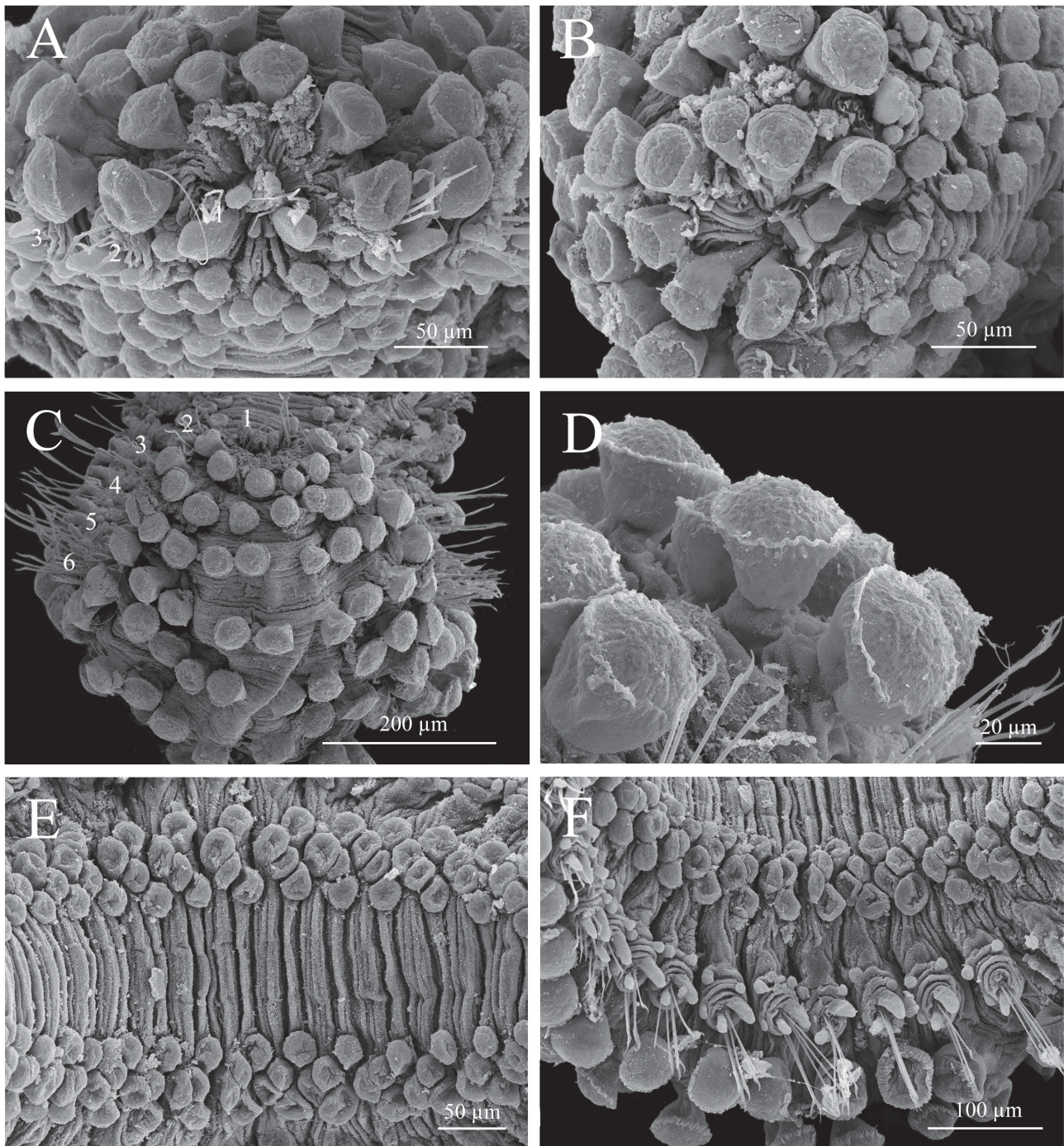




**FIGURE 8.** Scanning electron micrographs of *Sphaerodoridium songkhlaensis* sp. nov. (PSUZC-POL-0064). A. Prostomium, frontal view; B. Same, from specimen with invaginated front end. Abbreviations: lateral antenna la, median antenna ma, palp pa, tentacular cirri tc, ventral cirrus vc.



Hartmann-Schröder & Rosenfeldt, 1990 from the Antarctic Peninsula (262 m). *Sphaerodoridium campanulata* is distinguished from *S. songkhlaensis* **sp. nov.** in the number, size and arrangement of the dorsal macrotubercles, having two kinds of tubercles (some stalked and spherical and other bell-shaped), arranged in two transverse rows per segment (6–8 + 3–4), while *S. songkhlaensis* **sp. nov.** has similar shaped macrotubercles crowned by a conspicuous epithelial rim, arranged in a single transverse row.



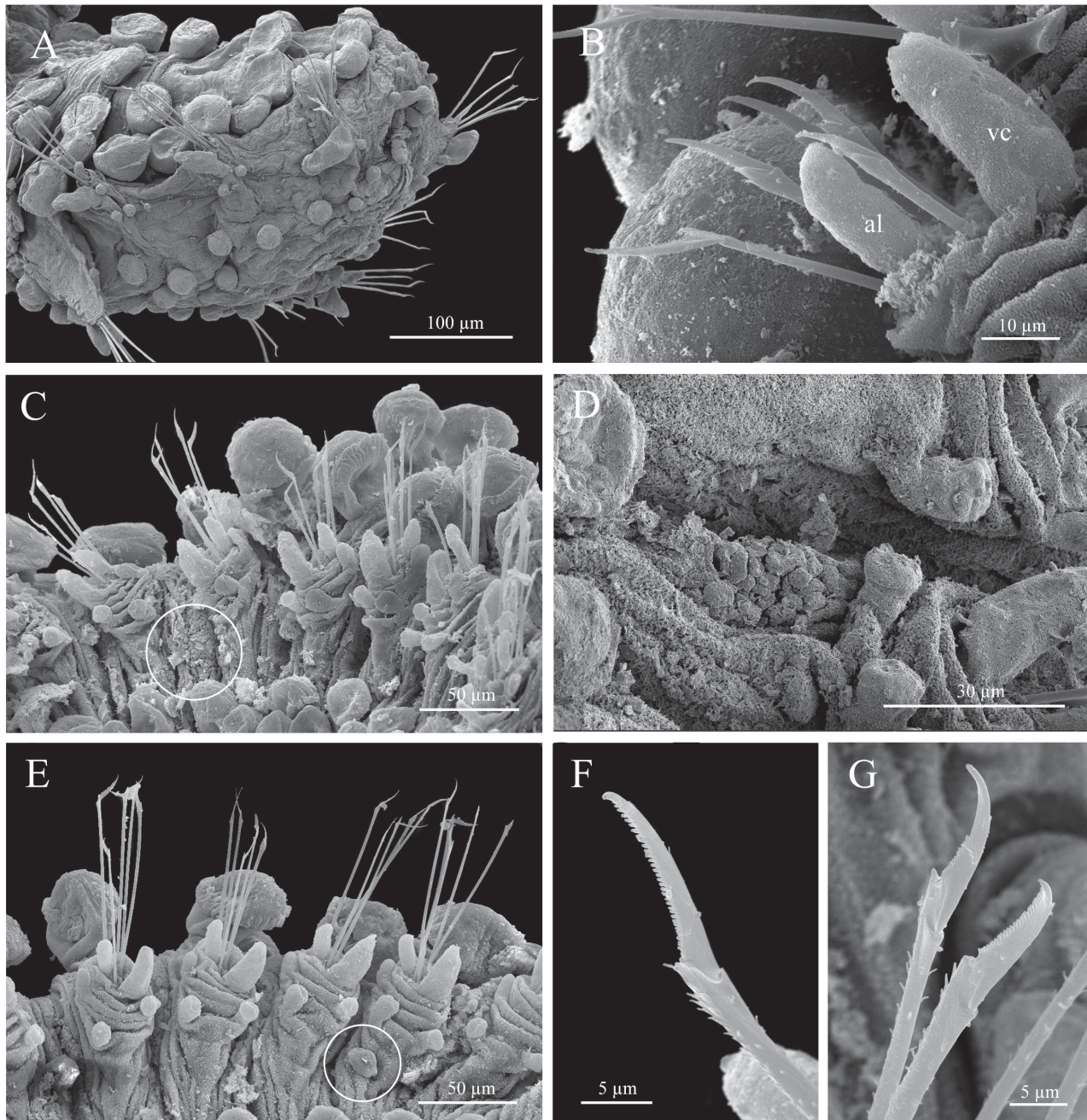
**FIGURE 9.** Scanning electron micrographs of *Sphaerodoridium songkhlaensis* **sp. nov.** (PSUZY-POL-0011-13). A, B. Anterior end, front view; C. Anterior end, dorsal view; D. Detail of macrotubercles, anterior chaetigers; E. Ventral tubercles, midbody chaetigers; F. Mid-body chaetigers, lateral view. Abbreviations: number of chaetigers 1–6.

*Sphaerodoridium andamanense* was described as bearing up to 10 dorsal macrotubercles per segment, like *S. songkhlaensis* **sp. nov.** Even though the original description did not give details about the shape of macrotubercles, the drawings indicate an inverted cone shape (corroborated by direct examination of holotype. Differences between *S. andamanense* and *S. songkhlaensis* **sp. nov.** rely in the length of the stalk of dorsal macrotubercles, almost twice



as long as the distal tubercle in *S. andamanense* (Bakken, 2002) and much shorter than the tubercle in *S. songkhlaensis* **sp. nov.**; in the conspicuous epithelial rim, absent in *S. andamanense*; and the number and arrangement of ventral tubercles: *S. andamanense* bears three pairs of long stalked tubercles per segment (Bakken 2002) and the new species bears four pairs of sessile tubercles.

*Sphaerodoridium songkhlaensis* **sp. nov.** differs from *Sphaerodoridium* sp. C (as *Sphaerodoropsis* in Bakken, 2002) in the size of the dorsal macrotubercles, similar in the new species, and showing conspicuous variation in *Sphaerodoropsis* sp. C. Moreover, the new species has a pair of eyes, absent in *Sphaerodoropsis* sp. C, bears 5–6 chaetae per fascicle, with blades variable within fascicles (4–6 times longer than maximum width) while *Sphaerodoropsis* sp. C bears 6–8 chaetae per fascicle, all with short blades (three times as long as wide). It would, however, be interesting to find more material of both morphotypes to establish differences between intraspecific and interspecific variation.



**FIGURE 10.** Scanning electron micrographs of *Sphaerodoridium songkhlaensis* **sp. nov.** (A. PSUZC-POL-0064, B–F. PSUZC-POL-0012). A. Anterior end, lateral view; B. Parapodium chaetiger 6; C. Parapodia chaetiger 5–9 with female copulatory organs located between chaetiger 8 and 9 (encircle), ventral view; D. Detail of female copulatory organs; E. Parapodia chaetiger 9–12 with male copulatory organs (encircle), ventral view; F–G. Compound chaetae. Abbreviation: acicular lobe al, ventral cirrus vc.

*Clavodorum antarcticum* resembles *S. songkhlaensis* **sp. nov.** in the shape of the dorsal macrotubercles, as inverted cones, however due to the number of longitudinal rows of macrotubercles they are considered members of different genera (*Clavodorum* with six and *Sphaerodoridium* more than six).

## Discussion

There are few benthic studies undertaken at the Songkhla Sea in the Gulf of Thailand, especially, in the petroleum concession area of Songkhla Province. This is the first long term research study (stations S01–S08, Fig. 1) located about 3–30 km from the shore and 10–30 m deep. As a result, this and a series of papers dealing with the polychaete diversity associated with these habitats are planned.

The number of sphaerodorids in the petroleum concession area of Songkhla Province is shown to be higher than similar studies in other localities in Thailand (e.g., Bakken 2002) or in other shallow areas in the Pacific Ocean (e.g., Capa & Rouse 2015). A possible explanation is the intense collecting effort by MEM during ten years, resulting in a great number of samples and consequently specimens. Moreover, there are only a few studies devoted to the benthic diversity in offshore the Gulf of Thailand, mainly focused on coastal habitat, mangrove ecosystems and Songkhla Lake (e.g., Angsupanich & Kuwabara 1995; Jaritkhuan *et al.* 2017; Phuttapreecha *et al.* 2018) and not specifically on polychaetes. It is plausible that a comprehensive study in other localities in the Gulf of Thailand, would increase the number of species and records of sphaerodorids.

It is interesting to highlight the fact that the species richness and abundance of polychaetes has shown to be higher in the petroleum concession area than outside the extraction area (pers. obs. for other polychaete families and present study for sphaerodorids). This area is protected from several human activities by the Petroleum Concession Law. The lack of trawling and all kinds of fishing activities results in an undisturbed seafloor. In addition, this area is also far away from coastal development; industrial factories, docks and river runoff that transports inorganic substances from the agriculture areas to the coast. All of these factors may explain the higher species richness and abundance of polychaetes in the extraction area than outside.

The systematic study of marine annelids and other benthic invertebrates has been neglected in Thailand for many years (Aungtonya 2002). An exception and a good example of a successful project involving national and international collaboration is the 'Biodiversity of the Andaman Sea Shelf, (BIOSHSELF), where several papers were devoted to polychaete taxonomy (e.g., Aungtonya *et al.* 2000; Aungtonya 2002; Aungtonya & Eibye-Jacobsen 2002 and references therein). The opportunity to run environmental monitoring studies in Songkhla Sea over 10 years provided a large number of specimens from the Gulf of Thailand. All specimens are well preserved and under current study, and preliminary results reveal the presence of several undescribed species and new records for Thailand.

As in many countries around the world, taxonomic experts are scarce and even decreasing (e.g., Hutchings 2017). In Thailand, people trained in taxonomic skills often work for environmental agencies and consulting companies, with little capacity to undertake basic taxonomic research due to lack of time or resources constraints. We conclude that it is crucial to invest funding and expertise in the diversity assessments of the benthic environments in the Songkhla Sea and Thai waters in order to assess the biodiversity and the environmental status in the coastal environments for their management and conservation and purposes.

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